BANGALORE ELECTRICITY SUPPLY COMPANY LIMITED

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Section – 6(C)

Technical Specifications for Line Reclosers and Load Break Switches

"Expansion of Distribution Automation System to Peri-Urban areas of Bangalore city, District Headquarters & Industrial areas across BESCOM Jurisdiction".

Issued By

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1. Introduction

This section of the bidding documents presents the Technical Specifications that apply to **Line Reclosers and Load Break Switches.** The specifications cover the supply and installation of SCADA-ready Line Reclosers (LRCs) and Load Break Switches (LBSs) within the overall context of the Employer's. For the purposes of these Technical Specifications, the LRC and LBS devices are commonly or collectively referred to as **sectionalizers**.

1.1 Key Sectionalizers Components

Key sectionalizers components are listed as follows:

- Pole-mounted Gang Operated three-phase LRC or LBS switch.
- Switch position indicator .
- Integrated line sensors for metering.
- Fault passage indicator (or equivalent).
- In case of LRC:
  - Line sensors for protection.
  - Protection relay and auto-reclose circuitry.
- Auxiliary transformer to provide a suitable source of AC voltage
- Switch power supply (SPS) including batteries and battery charger
- Local control panel
- Remote terminal unit (RTU) serving as the interface by which the DAS can monitor and control the sectionalizer
- Pole-mounted control cabinet housing, for example, the local control panel, SPS, and RTU
- Surge arresters
- All necessary cables, insulators, cross-arms, and other accessories to complete installation of each sectionalizer on Reinforced Cement Concrete Double-Pole or Pre-stressed Concrete Spun Pole structures as exist or will be erected by others.

The sectionalizer control cabinet shall be capable of housing a communication accessories. This communication accessories will be supplied and installed by others to enable communications between the DAS and the sectionalizer's RTU.

1.2 Specification Organization

These Technical Specifications are organized as follows:

- **Introduction.** This clause provides information concerning project background, scope of work, applicable standards, applicable environmental conditions, and general testing requirements. It also provides general sectionalizer and distribution network information.
- **Basic Design Features.** This clause includes some basic and common design features related to sectionalizer availability, maintainability, and life span along with relevant physical and electrical properties.
- **Line Recloser Characteristics.** This clause describes the general and specific characteristics that relate to the functional aspects of the line recloser components other than its RTU.
- **Load Break Switch Characteristics.** This clause describes the general and specific characteristics that relate to the functional aspects of the load break switch components other than its RTU.
- **Remote Terminal Units.** This clause identifies the required functional design characteristics of the RTUs that shall be provided as an integral part of the line reclosers and load break switches.
- **Test Sets.** This clause describes the requirements that relate to the sectionalizer test sets that are to be provided by the Contractor.
- **Surge Arrester Characteristics.** This clause describes the characteristics of the surge arresters that shall be supplied and installed to protect the pole-mounted sectionalizers from lightning and other possible causes of voltage surge.

1.3 Applicable Standards

The sectionalizers shall be manufactured to the highest quality consistent with best practice and workmanship and in full accord with the Contractor's quality assurance plan. The sectionalizers and the work associated with their installation shall conform to applicable Indian and international standards such as those listed in Table 1-1 below.

Table 1-1: Applicable Standards

Standard	Description
IEC 62271-111 2019 /IEEE C37.60	Standard requirements for Overhead Automatic Circuit Reclosers and Fault Interrupters for Alternating Current System up to 38 KV
IEC 62271-102	HV switchgear and control gear-Alternating current disconnector and earthing switches
IEC 62271-1	Alternating-current circuit-breakers
IEC 60529	Degrees of protection provided by enclosures (IP Code)
IEC 62262	Degrees of protection provided by enclosures for electrical equipment against mechanical impacts (IK Code)

IEC 60060-1	High-voltage test techniques
IEC 60060-3	High-voltage test techniques - Part 3
IEC 60947	Low voltage switchgear and control gear
IEC 61869-2 / IS 2705	Current Transformers
IEC 61869-3/ IS 3156	Voltage Transformers
IS 13573-2	Cable accessories for extruded power cable for Working Voltages from 3.3 kV up to and including 33kV
IS 2629	Practice for Hot Dip Galvanizing of iron and steel
IEC 61000-4-1	Electromagnetic Compatibility for relays
IEC 60099-4:2014	Metal-oxide surge arresters without gaps for AC systems

The Contractor's shall provide an English language copy of the applicable Indian and equivalent international standards met by the proposed sectionalizers.

1.4 Environmental Conditions

All materials supplied and installed shall be capable of operating without fault in a tropical climate that exhibits a high level of ultra-violet radiation and severe thunderstorms. Relevant environmental conditions are listed as follows:

- Maximum ambient air temperature …….. 50 ºC
- Minimum ambient air temperature …….. 10 ºC
- Maximum relative humidity …… 90 %
- Average thunder storm days per annum …….. 50
- Average rainfall per annum ……. 900 mm
- Maximum wind speed ……. 119 km/hr
- Altitude above mean sea level ……. 1200m

1.5 Distribution Network Electrical Parameters

The main parameters of the BESCOM distribution network are as follows:

- Nominal system voltage ..... 11 kV (rms)
- System voltage standard …..…… 11 kV (rms)
- Number of phases ……. 3
- Frequency ……. 50 Hz
- Variation in frequency ……. 49 Hz to 50.5 Hz
- Type of earthing …….. Solid
- Power frequency withstand voltage ……. 28 kV
- Basic impulse withstand voltage ……. 75 kV

2. Basic Design Features

All basic design features of the proposed sectionalizers shall be fully supported by the equipment actually delivered. The basic design features include those that relate to:

- Availability, maintainability and life span.
- Ability to operate in severe outdoor environmental conditions.
- Immunity to electrical stress and disturbance.
- Acceptable insulation properties.
- Acceptable surge suppression characteristics.

In these and all other specified respects, the sectionalizers shall meet or exceed the cited standards or, where appropriate, other equivalent industry standards.

2.1 Availability, Maintainability, and Life Span

2.1.1 Availability

The sectionalizer shall be designed to have a fully enclosed metal housing combined with single-phase insulation of all primary live parts to reduce the risk of internal faults to an absolute minimum and to provide a high degree of safety as well as availability. Nevertheless, manufacturer standard designs shall be used to the fullest extent possible.

Each sectionalizer shall exhibit an availability of greater than 99.5%. To ensure this high degree of availability, the sectionalizers shall be fabricated, assembled, and finished with workmanship of the highest production quality and shall conform to all applicable quality control standards. All materials comprising the sectionalizer shall be new, unused, and of the best industrial grade, and the sectionalizer shall incorporate all recent improvements in both design and materials. All components shall be of current production from reliable component manufacturers.

2.1.2 Maintainability

The Employer intends to be self-reliant for sectionalizer maintenance. To this end, the Contractor shall provide the support, documentation, and training necessary to configure, operate, and repair the sectionalizer. This shall include, but shall not be limited to the maintenance manuals and repair kits applicable to the Contractor's sectionalizer design.

The Employer prefers sectionalizer designs that do not require periodic preventive maintenance and inspections. To facilitate maintenance, modularity shall be employed in the design of the equipment. All major subassemblies shall carry permanent labels providing a cross-reference to the Contractor’s corresponding documentation.

2.1.3 Life Span

Each sectionalizer shall have a design life of at least 20 years from the date of commission. The Contractor shall make available, at no cost to the Employer, the manufacturing designs, drawings, and

the rights to manufacture any subassemblies that the manufacturer will not support or discontinues to support during this life span. The specific components of each sub-assembly shall be identified and referenced in Contractor-supplied documentation.

2.2 Outdoor Features

2.2.1 General

The sectionalizers shall be designed specifically for outdoor installation and, in this respect, shall be suitable for continuous operation in a tropical climate that includes exposure to severe frequently occurring thunderstorms. They shall also be suitable for conditions in which they will be exposed to heavy industrial pollution and high levels of airborne dust.

The equipment in the proposed outdoor sectionalizer shall be conformably coated to meet these climatic conditions. In this respect, standards such covering equipment, systems, operating conditions, and environmental conditions shall apply, which covers the classification of such conditions. In particular, the sectionalizer equipment shall have been type tested for continuous operation under the environmental conditions identified.

In addition to the above, materials promoting the growth of fungus or susceptibility to corrosion and heat degradation shall not be used, and steps shall be taken to provide rodent proof installations.

2.2.2 Corrosion Protection

Except for stainless steel, all steel surfaces that are not galvanized shall be treated to protect against corrosion. As a minimum, corrosion treatment shall include the following procedures:

- The surface shall be cleaned to bare material by mechanical or chemical means.
- One or more phosphatizing or priming coats of paint shall be applied to the bare surface using a zinc-based or epoxy primer.
- A finish coat with high scratch resistance or epoxy powder finish paint shall be applied over the primer. The coat thickness shall be of the order of 120 micrometers.
- The finish coat color would be RAL-7032.

2.2.3 Galvanizing

Except for stainless steel, and unless otherwise stated, all structural steel and all exterior and interior steel surfaces of the sectionalizers, as well as nuts and bolts associated with galvanized parts, shall be hot-dipped galvanized in accordance with an equivalent international standard.

2.3 Immunity to Electrical Stress and Disturbance

The electrical and electronic components of the sectionalizer shall conform to relevant standards concerning insulation, isolation, and immunity from electromagnetic interference, radiated

disturbance, and electrostatic discharge. The ability to meet these requirements shall have been verified by type tests carried out by accredited test laboratories that are independent of the bidder and/or the manufacturer of the sectionalizer components. Certified copies of all available type test certificates and test results shall be included as part of the bidder's proposal. Failure to conform to this requirement may constitute grounds for rejection of the proposal.

2.4 Minimum Insulation of Equipment

The sectionalizers shall be solid dielectric insulated type. Otherwise, from an insulation perspective, the sectionalizer shall be designed so as to minimize exposure to electrically live terminals when visual inspection or maintenance of the internal components is being conducted.

2.5 Surge Voltage Suppression

The sectionalizer equipment shall be designed to operate on input power containing transient voltage surges. In particular, surge-voltage suppression devices shall be provided and properly installed to include suitable GI wire sizes connected to separate earth pits. Equipment shall be protected against part failure or malfunction such as intermittent firing of triggering devices due to voltage surges occurring randomly over the instantaneous supply voltage.

2.6 Nameplate Information

Sectionalizer nameplate information shall be determined in agreement with the Employer. This information may include for example:

- Name of manufacturer and country
- Type, design, and serial number
- Rated voltage and current
- Rated frequency(f)
- Rated short duration power frequency withstand voltage (Ud)
- Rated lightning impulse withstand voltage (Up)
- Short time withstand current and its duration.
- Rated symmetrical breaking capacity
  Rated making capacity
- Auxiliary control voltage (Ua)
- Internal Arc Classification.
- Operating cycle.
- Month and year of supply
- Purchase Order number and date
- Project details
- Height and Weight of the SPB
- SF6 pressure details.
- Protection relay details.

The name plate and a BESCOM logo shall be engraved with all the above information and each sectionalizer shall exhibit a "Danger Board" as used to indicate the presence of high voltage (11,000 Volts).

2.7 Interconnecting Cables, Wiring, Connectors, and Terminal Blocks

The Contractor shall provide all interconnecting wires, cables, connectors, terminations, and other wiring accessories such as terminal blocks required by the sectionalizer.

2.7.1 Metallic Cables

All metallic cables and wiring shall be of required cross-section solid or multiple strands of round copper conductors and have flame retardant insulation. All wiring shall be neatly laced and clamped.

All wire and cable connectors and terminators shall be permanently labeled for identification. All connection points for external cables and wires shall be easily accessible for connection and disconnection and shall be permanently labeled. Conductors in multi-conductor cables shall be individually color-coded.

2.7.2 Connectors

Plug-type connectors with captive fasteners are preferred for all interconnections. The connectors shall be polarized to prevent improper assembly.

2.7.3 Terminal Blocks

Apart from the connectors described above, heavy-duty terminal blocks with screw type terminals for 5 mm minimum machine screws shall be provided by the Contractor as may be necessary for other metallic cable terminations. In using a terminal block, no more than two cables or wires shall be connected to any of its individual terminals.

Self-extinguishing fireproof vinyl marking strips shall be used to identify all external connection blocks. Marking tags shall be read horizontally. All terminals to which battery or other high voltages are connected shall be provided with fireproof covers.

All individual status input, AC voltage input, and control output points shall be isolatable without the need to remove wiring by means of individual terminal blocks of the removable link type. In order to avoid open circuits on the secondary side of CTs, termination blocks with by-pass bridges shall be provided for all AC current inputs. Terminal blocks shall comply with relevant IEC standards.

3. Line Recloser Characteristics

As a minimum, each Line Recloser (LRC) shall be a SCADA-ready device equipped with circuit breakers, protection relay, auto-reclose circuitry, switch position indicator, line sensors consisting of PTs and CTs, fault passage indicator (or equivalent), and metering devices or circuitry providing voltage, current, power, energy, and power factor readings. In addition, each LRC shall be equipped with an auxiliary transformer, control cabinet, local control panel, RTU, switch power supply, all necessary cables, connectors, and terminal blocks, and all other accessories such as insulators and cross-arms required to erect the LRC components on available pole structures.

3.1 Functional Requirements

The LRCs shall act autonomously for the purpose of protecting feeders upon detection of overcurrent and earth fault conditions. In this respect, each LRC shall be capable of tripping and re-closing on a configurable basis up to three times in the presence of momentary faults and subsequently of tripping and locking out should the fault not be cleared as a result of the initial switching operations. On lockout, the presence of a sustained or permanent fault will be assumed.

The LRC via its integral RTU shall also be capable of being monitored and controlled by the DAS. Monitoring shall include indications and measurements corresponding to the LRC and RTU as well as the feeder where the LRC is located. Control shall include the ability of the DAS under manual or application supervisory control to open and close the LRC circuit breakers. Control from the DAS, however, shall be capable of being enabled and disabled by a manually operated local/remote switch to be provided with the LRC.

3.2 General Characteristics

The required general characteristics of the LRC are presented in Table 3-1 below.

3.3 Switch Features

Each set of LRC switches shall include the following features:

1) A closed-position mechanical-latch to prevent switch contacts from opening through loss of line voltage.

2) Switch operation manually without power supply using a NEMA-head (or equivalent) hook stick and electrically using an internal operating mechanism and control unit.

3) Puffer type switch or one that is based on a combination of the rotary and puffer arc-quenching principle.

4) No leakage currents under any circumstance from any pole terminal on one side of the switch to any pole terminal on the other side of the switch when the switch is in its off-position.

Table 3-1: Line Recloser Characteristics

Sl.No.	Particulars	Values/Requirements
1	Nominal system voltage	11kV rms
2	Highest system voltage	12kV rms
3	Frequency	50Hz ±5%
4	Number of Phases	3 Phase
5	Rated Continuous current	600A
6	Rated Short Circuit breaking capacity (kA)	20kA
7	Rated Short Circuit making capacity (kAp)	50kA peak
8	Rated Short Circuit current withstand time	21kA for 3 sec
9	Rated Power frequency dry withstand voltage	28 KV rms for 1 minute or better
10	Rated Power frequency wet withstand voltage	28 KV rms for 1 minute or better
11	Rated lightning impulse withstand peak voltage (BIL) (1.2/50micro sec)	75 kV peak
12	Minimum Creepage distance	31 mm/ kV
13	Interrupting Medium Re-closer	Vacuum (VCB)
14	Operating Mechanism	Permanent Magnetic Actuator
15	Insulation Material	Solid Dielectric (HCEP or equivalent)
15	Minimum no. of rated load operations	10,000 Nos.
16	CT Ratio	400/1A
17	CT type accuracy	5P20
18	Auxiliary PT/VT ratio, 2 Phase (For power supply to control panel)	11000 / 230 volts, 500VA
19	Type PT/VT	Outdoor double pole cast resin.
20	Potential Transformer for measurement of voltage	11kV/√3/110V/√3, Acc. Class-1, 100VA
21	Voltage factor	1.2 Continues, 1.9 for 8Hours
22	Insulation level	12/28/95 KV peak
23	Operating Sequence /Duty cycle	O-0.3s-CO-1s-CO-1s-CO 1st Reclosing : 0.1 ~ 1,800sec (Adjustable) 2nd ~ 4th Reclosing : 1 ~ 1,800sec (Adjustable) (Adjustable in steps of 0.01sec)
24	Degree of Protection for switching & control unit	IP-68
25	Dead or live line detection	Capable of detecting voltage presence or absence in the feeder for safe reclosing
26	Surge Arrestor (Porcelain housed/polymeric)	9.6kV, 10kA

5) Switch opening and closing times at rated normal current, as initiated from the local LRC control panel, shall not be more than two (2) seconds. The opening and closing times shall be measured as follows:

   - Timing shall start when the switch open or close action is initiated
   - Timing shall end when the switch position indicator changes state.

6) Dust-tight and waterproof switch enclosures of stainless steel type 316L. Gasket and bolted seals shall not be used on pressurized tanks. Bushings, however, may be sealed using "O" rings. Water condensation shall be prevented.

7) Enclosures with standard protection against corrosion. The finishing coat shall be grey (RAL 7032).

8) Manual operating handle with operating hook(s) suitable for use with a NEMA-head (or equivalent) hook stick from ground level. At least one hook stick of suitable length shall be provided for every 5 LRCs.

9) Mechanical ON/OFF switch position indicator clearly visible from ground level.

10) Tripping device.

11) Closing device.

12) Auxiliary contacts for status indicators and signals.

13) Six (6) main circuit leads of suitable length consisting of insulated copper conductors with sets of cable-end water-seals and sets of compression type terminal connectors.

14) One (1) bar-tap tee connector per main circuit lead for connecting to ACSR conductors of size Coyote and Rabbit.

15) Control cable(s) of suitable length with outdoor-rated connectors at each end for connecting to mating connectors on the switches and on the bottom of the LRC control cabinet.

16) All control cables shall be shielded from electromagnetic interference (EMI) and radio frequency (RF) interference.

17) Cable(s) of suitable length with plug terminal for connecting between the voltage sensors and the control cabinet.

18) Ground terminal with solder-less clamp-type connector suitable for steel stranded conductor and complete with lock washer of stainless steel or better.

19) Pressure releasing device for protection against pressure build-up higher than the permissible design pressure, but for switches of dead-tank type only.

20) Mechanical locking lever having two (2) positions of “FREE” and “LOCK”. When in “LOCK” position, switches can not be closed manually or electrically from the local control panel or DAS.

21) Bushings of polymer or cyclo-aliphatic epoxy resin material.

22) Lifting lug(s).

23) Nameplate.

24) Mounting bracket made of galvanized steel and hardware (i.e., bolt, nut, flat washer, spring lock washer) of stainless steel or better.

25) Other features according to manufacturer’s design

3.4 Line Sensor Features

The LRC shall be provided with current sensors and voltage sensors. These sensors shall meet the electrical and mechanical ratings as per the relevant standards referenced in Table 1-1.

3.4.1 Current Sensors

The current sensors shall be of bushing current-transformer type. They shall be able to measure load and fault currents through the switches on each phase and supply current input to the LRC’s integral Remote Terminal Unit (RTU).

The output of the current sensors shall be in accordance with the sectionalizer’s design. As a minimum, however, they shall have an accuracy of ±2.5% or better at rated normal current and ±10% or better at twenty (20) times rated normal current. This accuracy shall be maintained while the sensors are connected to the RTU current input card and other equipment according to the manufacturer’s design.

The current sensors shall provide protection against open secondary circuit voltages.

3.4.2 Voltage Sensors

The voltage sensors shall be able to measure voltages at the LRC switch terminals (6 voltages) and supply these voltage inputs to the RTU.

The output of the voltage sensors shall be in accordance with the sectionalizer’s design. As a minimum, however, the voltage sensors shall have an accuracy of ±2.5% or better at rated normal voltage. This accuracy shall be maintained while connected to the RTU voltage input card and other equipment according to the manufacturer’s design.

The voltage sensors shall be of three-phase inductive voltage transformer type in YNyn0 connection.

Terminals on the HV side shall be equipped with solder-less clamp-type terminal connectors for different ACSR conductors.

3.5 Protection Features

3.5.1 General

The LRC protection features shall meet the following requirements as a minimum:

1) The ratio of drop-off current to pick-up current shall be at least 90% for all protection functions.

2) All protection functions, i.e., over-current (O/C), earth fault (E/F), and sensitive earth fault (SEF) shall have elements with characteristics that comply with relevant standards.

3) The Sensitive Earth Fault (SEF) function shall be equipped with harmonic filtering to prevent operation when harmonics are present in the primary residual earth currents.

4) A suitable low pass filter with 3rd harmonic rejection shall be supplied. Both the SEF function and its filter shall be described in the Contractor's bid.

5) The sequence of trip and auto-reclose characteristics for O/C, E/F, and SEF shall be programmable to enable:

    a) Selection of any combination of the available elements for each trip in the trip-reclose sequence

    b) Separate trip-reclose sequences for O/C, E/F, and SEF with the same number of reclosing intervals for O/C and E/F.

6) In case of inverse definite minimum time lag (IDMTL) protection elements, the LRC shall preferably be provided with a disc reset timer that simulates the resetting functionality of an upstream electromechanical induction disc relay by implementing a disc reset timer. The length of the time delay shall preferably be settable to be able to simulate the upstream device.

7) Provision of a trip-close feature allowing coordination where combinations of rapid and delayed protection operations are applied to LRCs in series. This sequence coordination function shall be such that the LRC:

    a) Senses the presence of an over-current or earth fault as well as clearance of this fault by a downstream device and proceeds to the next protection operation in its own sequence.

    b) Proceeds in its sequence of rapid protection operations only, allowing the full number of delayed operations to be executed for in zone conditions.

8) The LRC and its control element shall support multiple protection groups as follows:

   a) The LRC shall have a minimum of 4 independent protection groups. The Protection Groups shall have a clear indication and shall be marked as "I, II, III, IV" or "A, B, C, D."

   b) Each protection group shall have the facility to configure O/C, E/F, and SEF trip current and specify the number of the protection trips independently from others. The protection functions and parameters used in one of the protection groups shall be available for use in any or all of the other protection groups.

   c) Changes to any protection parameter corresponding to any of the non-active protection groups shall not affect the protection functionality of the active protection group.

   d) Information about activation of any protection group shall be recorded and saved and shall be easily accessible.

   e) Information about protection tripping shall clearly indicate the protection group that is active at the time of fault.

   f) Facility for Automatic Protection Group Selection shall be provided. This shall include the capability to turn Automatic Protection Group Selection ON and OFF with password protection or other form of access control.

   g) Type of fault on which recloser activated shall be mentioned clearly as tripped on timer, Instantaneous.

3.5.2 Over-Current Function

The supplied over-current function shall meet the following requirements:

1) Delayed protection operation shall be possible by selecting an IDMTL protection element with normal inverse (NI), very inverse (VI), or extremely inverse (El) curves. Provision shall also be made for customized protection curves.

2) Both the process and software tools required for creating these protection curves shall be described in the Contractor's bid. The over-current pick-up setting range shall be selectable from 10 A to 630 A in suitable steps. The time multiplier setting shall be selectable from 0.01 to 2s in steps starting from 0.01s..

3) Rapid protection operation shall be possible by selecting a fast curve or instantaneous protection element. Co-ordination of the fast curves or instantaneous protection elements between two devices in series shall be possible either by selecting suitable curves from a family or by addition of a selectable time increment or any other acceptable solution.

4) Long protection operating times associated with fault levels marginally above the pick-up setting of the IDMTL protection element shall be avoided by the provision of a Low Set Definite Time element with the following features:

   a) It shall be possible to enable or disable the element. When enabled it shall be active simultaneously as an overlay with all selected elements.

   b) The element shall have the same pick-up current setting as the IDMTL element.

   c) The time delay shall be selectable in steps. Time delays shall be independent of any curve manipulation.

5) A High Set Instantaneous element with the following features:

   a) It shall be possible to enable or disable the element. When enabled it shall be active simultaneously as an overlay with all selected elements.

   b) Circuit-breaker lock-out as a result of an operation due to the High Set Instantaneous element shall be selectable.

   c) The pick-up setting range of this element shall be at least 50% to 1500% of the over-current setting and shall be independent of any curve manipulation.

   d) The time delay shall be selectable in steps starting from 0s. Time delays shall be independent of any curve manipulation.

6) A cold load pick-up (CLP) feature shall be provided that allows user selectable modification of protection element characteristics under conditions of distribution network power restoration. The CLP function's methodology shall be described in the Contractor's bid.

3.5.3 Earth Fault Function

The supplied earth fault function shall meet the following requirements:

1) The earth fault setting range shall detect primary earth fault currents down to 5A to 250A The time multiplier setting shall be selectable from 0.01 to 2s in steps starting from 0.01s.

2) Delayed protection operation shall be possible by selecting an IDMTL element with a NI, VI, or El curve or a definite time protection element with time delay.

3) Rapid protection operation shall be possible by selecting a fast curve or instantaneous protection element.

4) Co-ordination of the fast curves or instantaneous protection elements between two devices in series shall be possible either by selecting suitable curves from a family or by addition of a selectable time increment or any other acceptable solution.

5) A High-Set Instantaneous element shall be provided with the following features:

   a) It shall be possible to enable or disable the element. When enabled it shall be active simultaneously as an overlay with all selected elements

   b) Circuit-breaker lockout as a result of an operation due to the High-Set Instantaneous element shall be selectable

   c) The pick-up setting range of this element shall be at least 10% to 1500% of the earth fault setting and shall be independent of any curve manipulation

   d) The time delay shall be selectable in steps starting from 0s and it shall be selectable in suitable steps. The time delay shall be independent of any curve manipulation.

3.5.4 Sensitive Earth Fault Function

The requirements to be met by the Sensitive Earth Fault function shall include:

1) Detection of a primary earth fault current of 4 A to 20 A in steps not exceeding 1 A.

2) Delayed protection operation by selecting a definite time protection element with a time delay from 3 to 25 seconds in 1 second steps.

3.5.5 Reclose Parameters

The following minimum requirements relate to the LRC's reclose parameters:

1) The number of sequential trips to reach lockout shall be selectable to be 1, 2, 3, or 4.

2) Reset times shall ideally be separately selectable for SEF and the combination of over-current and earth fault functions. The reset time shall be selectable.

3) Dead times shall ideally be selectable for SEF and the combination of over-current and earth fault functions. The dead time between each successive reclose operation shall be independently selectable.

4) A close instruction initiated locally or remotely during a dead time shall result in lockout if the fault is still present upon closure.

3.6 Local Control Panel

The LRC shall be furnished with a local swing-type control panel for initiating control actions and viewing switch status indicators. As a minimum, the local control panel shall include the following features:

1) Separate discrepancy switches for opening and closing the LRC switches. Discrepancy switch operation shall be possible using the backup power supply system when the AC power supply is off.

2) A Remote/Local switch. While this switch is in the "Local" position, control shall be permitted only from the local control panel (i.e., remote control shall be disabled). While this switch is in its "Remote" position, control shall be permitted from either the DAS or the control panel.

3) Separate "Open" (green) and "Close" (red) status LED super bright pilot lamps or better to indicate the status of the LRC switches.

4) An operation counter to indicate the number of LRC switching cycles. The operation counter shall increment for electrical operations (both remote and local control) and for mechanical operations (e.g., hook-stick).

5) Other control panel features in accordance with the manufacturer's LRC design.

3.7 Distribution Automation System Interface

The LRC shall be monitored and controlled by the DAS. In this respect, the LRC's integral RTU shall be capable of interfacing with the radio to be supplied and installed in the LRC control cabinet.

3.8 Control Cabinet

Each LRC shall include a pole-mounted control cabinet. The control cabinet shall house the LRC's Local Control Panel, Switch Power Supply (SPS), and RTU and any other device as may be required in accordance with the LRC manufacturer's design. Space within the cabinet shall allow for the installation of the remote radio as supplied and installed by others.

The control cabinet shall meet the following requirements:

1) All electronic parts shall be enclosed in modules that protect them from entry of small insects. The power supply module in particular shall be physically separated from all other modules.

2) The control cabinet shall be manufactured such that ingress of dust, vermin, and small objects is prohibited.

3) The electronic component modules within the control cabinet shall have a minimum protection level of IP 56 or better. The control cabinet itself shall have an overall protection level of at least IP 56 or better.

4) Holes with a metal screen shall be provided at the top and bottom of the control cabinet to provide ventilation in such a way as to avoid condensation within the cabinet while still

maintaining the cabinet's IP 56 protection level, i.e., such ventilation shall in no way reduce the effectiveness of the control cabinet's water-tight, dust-tight, and corrosion-resistant characteristics. In this respect, the control cabinet shall be tested in accordance with the latest IEC standards.

5) The control cabinet shall have a hinged front access door with three-point latch locking system and latch operating lockable handle.

6) A number lock/Digital lock of adequate size shall be provided to Control Cabinet.

7) The opening of the cabinet behind the door shall have a perimeter flange and gasket (rubber or neoprene) to prevent the ingress of water.

8) The control cabinet shall include a weather-sealed hole with double compression cable gland, approximately 30 mm in diameter, on the bottom of the cabinet for routing the remote radio's antenna cable.

8) The control cabinet shall be fabricated from sheet steel of not less than 2 mm in thickness.

9) The finishing coat shall be grey (RAL 7032).

10) The control cabinet shall be suitable for mounting on poles consisting, for example, of reinforced cement concrete double-pole or single spun-pole structures.

11) The cabinet shall have a steel channel fixed to the back of the control cabinet for mounting purposes.

12) The control cabinet shall be provided with:

    a) Weatherproof fittings for control cables.

    b) Grounding terminal, with solder-less clamp type connector suitable for steel stranded conductor, complete with lock washer of stainless steel or better.

    c) Circuit diagram of control unit for maintenance purposes, to be affixed permanently and legibly marked

    d) Other items per manufacturer's design.

3.9 Auxiliary Power Transformer

The LRC shall provide a single-phase auxiliary power transformer of outdoor cyclo-aliphatic resin cast type. The transformer shall be suitable for phase-to-ground connection to the 11-kV distribution network in order to provide a 230 VAC, 500vA output for distribution to the SPS as used, for

example, to power the LRC switch gear, RTU, and remote radio. The auxiliary power transformer shall be pole-mounted (ideally on the same pole structure on which the LRC will be mounted), and shall be properly earthed via a GI strip of suitable size.

3.10 Switch Power Supply

The LRC shall be equipped with a Switch Power Supply (SPS) consisting of batteries and battery charger. Power from the SPS shall be sufficient to supply the LRC equipment. This includes the RTU. It also includes the radio (supplied and installed by others).

The SPS shall meet the following requirements:

1) Battery standby time shall not be less than 8 hours and shall allow for a minimum of ten (10) sequences of LRC trip-close operations and a transmit/receive standby duty cycle of 10/90 percent with respect to the radio/modem.

2) The battery shall recharge to 100 % of its capacity in a maximum of 8 hours.

3) Under the above communications scenario, closing of the LRC circuit breakers shall be prevented if the battery does not have enough stored energy to open the breakers for a protection trip condition.

4) Batteries shall be disconnected at the manufacturer's specified minimum voltage.

5) “Battery Low” indications shall be available locally and remotely and shall include a battery test. The indication of "Battery Low" status shall allow for a further ten LRC switch operations. A “Battery Off” indication shall also be provided locally and remotely to show that the battery needs to be replaced.

   - The backup battery bank shall include 2 Numbers of Lithium Iron Phosphate (LiFePO4) (LFP) 12 VDC, 42Ah each.
   - Each Lithium Iron Phosphate (LiFePO4) battery system shall be provided with an integrated BMS providing : cell voltage and temperature monitoring, state-of-charge and state-of-health estimation, cell balancing, over/under-voltage, over/under-temperature, over-current and short-circuit protection.
   - Battery compartment shall feature a theft-proof enclosure of 2mm thick stainless steel (Grade 316, IP54 rated), secured solely by M8 shear-head vandal-proof nuts/bolts. Tamper detection via NC micro-switch on seams/hinges shall trigger a 100 dB piezoelectric hooter with LED strobe (latched, DC-backed), silenced via separate external "Acknowledge" button while retaining LED, and reset via distinct "Reset" button post-rectification; alarms integrate with RTU/SCADA. All wiring, including battery links and sensors, shall use armored cut-proof cables (2.5 sq mm copper with steel braid/sheath resistant to cutters/grinders).
   - Receptacles: 1 x 230 VAC (for test equipment)

6) The minimum battery life expectancy shall be 10 years at 25^{o}C.

7) The battery charger shall be fully temperature compensated.

8) The SPS shall supply 24 VDC power to the terminal blocks for the trip coil and close coil.

9) To prevent deep discharge of the batteries on loss of AC power, the battery charger shall automatically disconnect all circuitry fed by the batteries (except for the radio) following a user-adjustable time period or when the battery bank voltage falls below a preset value. If the voltage falls below the preset value, the time to fully recharge all batteries shall not exceed 8 hours.

10) In order to prevent serious battery discharge, the direct current power will be cut off when voltage stays under the minimum preset value.

11) An automatic battery checking device shall be provided to check the health of the batteries and initiate a battery failed alarm signal in case deterioration is detected. Detection may be based on a comparison of measured values versus setting or nominal values, e.g., internal resistance, voltage, etc.

12) Battery chargers shall be provided with the following alarms as a minimum:

    a) Low battery voltage alarm

    b) High battery voltage alarm

    c) Battery failed alarm

    d) Battery charger overvoltage alarm

    e) Grounded battery or battery-charger alarm

    f) Battery Temperature

    g) Others according to manufacturer's design

14) Each alarm indicator shall be displayed on the local control panel and as in Table 5-1 for remote indication.

15) The SPS shall provide the radio with a stable - 12 VDC source of power for Radio/ Modem.

3.11 Measurement Functions

The equipment supplied with the LRC shall meet the following requirements with respect to the measurements to be derived from primary voltage and current values:

1) Measurements shall be carried out by the three-phase, 3-wire method and/or the three-phase, 4-wire method and shall be made available locally and remotely.

2) All three phase voltages shall be measured on both sides of the LRC and, on this basis, shall be used to identify the live and dead sides when the LRC is in the open position.

3) All three phase currents shall be measured.

4) The following list identifies the minimum required measurements and accuracies:
   a) Phase Voltage (V) ……..... ±2.5% of rated voltage
   b) Phase Current (A) …… ±2.5% of rated current
   c) Three phase active Power (kW) …….. ± 5 %
   d) Three phase reactive power (kVAr) …… ± 5 %
   e) Total three-phase active energy (kWh) …... ± 5 %
   f) Power factor ...…….. ± 5 %
   g) Maximum demand ……..... ± 5 %

3) Energy values shall be calculated with selectable time integration periods of 15, 30, or 60 minutes. The data buffer shall work on the FIFO principle and shall have the capacity to store the required energy values for 1 week based on a 60 minute integration period.

4) The LRC shall have the facility to record the number and duration of outages. The information shall be accessible locally as well as remotely at the DAS.

5) The following parameters shall be recorded and made available locally and at the DAS:

   a) Cumulative total number of outages

   b) Cumulative total outage duration

   c) Time and duration of each outage

   d) Number of switch operations

3.12 Earthing

Two No's of separate Rod type earthing to be provided. The earthing has to confirm to relevant IS. The details of earthing to be provided are as given under:

1. Auxiliary Transformer neutral, Auxiliary Transformer body, Auto Reclosers body, control cabinet and all other metallic parts of the structure to be earthed separately using 25 x 3 mm GI strip.

2. Surge arrester / Lighting arrester to be earthed separately using 25 x 3 mm GI strip.

4. Load Break Switch Characteristics

As a minimum, each Load Break Switch (LBS) shall be a SCADA-ready device equipped with switches, switch position indicator, line sensors consisting of PTs and CTs, fault passage indicator (or equivalent), and metering devices or circuitry providing voltage, current, power, energy, and power factor readings. In addition, each LBS shall be equipped with an auxiliary transformer, control cabinet, local control panel, RTU, switch power supply, all necessary cables, connectors, and terminal

blocks, and all other accessories such as insulators and cross-arms required to erect the LBS components on available pole structures.

4.1 Functional Requirements

Each LBS via its integral RTU shall be capable of being monitored and controlled by the DAS. Monitoring shall include indications and measurements corresponding to the LBS and RTU as well as the feeder where the LBS will be located. Control shall include the ability of the DAS under manual or application supervisory control to open and close the LBS switches. Control from the DAS, however, shall be capable of being enabled and disabled by a manually operated local/remote switch to be provided with the LBS.

4.2 General Characteristics

The required general characteristics of the LBS are presented in the following table:

Table 4-1: Load Break Switch Characteristics

Parameter	Value
Nominal system voltage (r.m.s.)	11 kV
System standard voltage (r.m.s.)	11 kV
Load current	630 A
Rated short-time withstand current for 3 second	16 kA
Rated short-circuit making current	Not less than 31.25 kA (peak)
Rated power frequency withstand voltage for 1 minute	Not less than 28 kV
Number of operations: Mechanical & Electrical (at rated normal current)	Not less than 10,000
Minimum creepage distance of bushing or supporting insulator from live part to ground	600 mm minimum.
Lightning Impulse Withstand Voltage (BIL)	110 kV (peak) minimum.
System frequency	50 Hz
Number of phases	3
Interrupting medium	Vacuum Interrupter
Insulation medium	Solid dielectric
Minimum number of rated load operations	10,000
Closing & Opening Mechanism	Permanent Magnetic Actuator

4.3 Switch Features

Each set of LBS switches shall include the following features:

1) A closed-position mechanical-latch to prevent switch contacts from opening through loss of line voltage.
2) Switch operation manually without power supply using a NEMA-head (or equivalent) hook stick and electrically using an internal operating mechanism and control unit.
3) Puffer type switch or one that is based on a combination of the rotary and puffer arc-quenching principle.

4) No leakage currents under any circumstance from any pole terminal on one side of the switch to any pole terminal on the other side of the switch when the switch is in its off-position.
5) Switch opening and closing times at rated normal current, as initiated from the local LBS control panel, shall not be more than two (2) seconds. The opening and closing times shall be measured as follows:
    - Timing shall start when the switch open or close action is initiated
    - Timing shall end when the switch position indicator changes state.
6) Dust-tight and waterproof switch enclosures of stainless steel type 316L. Gasket and bolted seals shall not be used on pressurized tanks. Bushings, however, may be sealed using "O" rings. Water condensation shall be prevented.
7) Enclosures with standard protection against corrosion. The finishing coat shall be grey (RAL 7032).
8) Manual operating handle with operating hook(s) suitable for use with a NEMA-head (or equivalent) hook stick from ground level. At least one hook stick of suitable length shall be provided for every 5 LBSs.
9) Mechanical ON/OFF switch position indicator clearly visible from ground level.
10) Opening device.
11) Closing device.
12) Auxiliary contacts for status indicators and signals.
13) Six (6) main circuit leads of suitable length consisting of insulated copper conductors with sets of cable-end water-seals and sets of compression type terminal connectors.
14) One (1) bar-tap tee connector per main circuit lead for connecting to ACSR conductors of size Coyote and Rabbit.
15) Control cable(s) of suitable length with outdoor-rated connectors at each end for connecting to mating connectors on the switches and on the bottom of the LBS control cabinet.
16) All control cables shall be shielded from electromagnetic interference (EMI) and radio frequency (RF) interference.
17) Cable(s) of suitable length with plug terminal for connecting between the voltage sensors and control cabinet.
18) Ground terminal with solderless clamp-type connector suitable for steel stranded conductor and complete with lock washer of stainless steel or better.
19) Pressure releasing device for protection against pressure build-up higher than the permissible design pressure, but for switches of dead-tank type only.
20) Mechanical locking lever having two (2) positions of "FREE" and "LOCK". When in "LOCK" position, switches can not be closed manually or electrically from the local control panel or DAS.
21) Bushings of polymer or cyclo-aliphatic epoxy resin material.
22) Lifting lug(s).
23) Nameplate.
24) Mounting bracket made of galvanized steel and hardware (i.e., bolt, nut flat washer, spring lock washer) of stainless steel or better.
25) Other features according to manufacturer's design.

4.4 Line Sensor Features

The LBS shall be provided with current sensors and voltage sensors. These sensors shall meet the electrical and mechanical ratings as per the relevant standards referenced in Table 1-1.

4.4.1 Current Sensors

The current sensors shall be of bushing current-transformer type. They shall be able to measure load and fault currents through the switches on each phase and supply current input to the LBS's integral Remote Terminal Unit (RTU).

The output of the current sensors shall be in accordance with the sectionalizer's design. As a minimum, however, they shall have an accuracy of ±2.5% or better at rated normal current and ±10% or better at twenty (20) times rated normal current. This accuracy shall be maintained while the sensors are connected to the RTU current input card and other equipment according to the manufacturer's design.

The current sensors shall provide protection against open secondary circuit voltages.

4.4.2 Voltage Sensors

The voltage sensors shall be able to measure voltages at the LBS switch terminals (6 voltages) and supply these voltage inputs to the RTU.

The output of the voltage sensors shall be in accordance with the sectionalizer's design. As a minimum, however, the voltage sensors shall have an accuracy of ±2.5% or better at rated normal voltage. This accuracy shall be maintained while connected to the RTU voltage input card and other equipment according to the manufacturer's design.

The voltage sensors shall be of three-phase inductive voltage transformer type in YNyn0 connection.

Terminals on the HV side shall be equipped with solder-less clamp-type terminal connectors for different ACSR conductors.

4.5 Local Control Panel

The LBS shall be furnished with a local swing-type control panel for initiating control actions and viewing switch status indicators. As a minimum, the local control panel shall include the following features:

1) Separate discrepancy switches for opening and closing the LRC switches. Discrepancy switch operation shall be possible using the backup power supply system when the AC power supply is off.

2) A Local/Remote switch. While this switch is in the "Local" position, control shall be permitted only from the local control panel (i.e., remote control shall be disabled). While

this switch is in its “Remote” position, control shall be permitted from either the DAS or the control panel.

3) Separate “Open” (green) and “Close” (red) status LED super bright pilot lamps or better to indicate the status of the LBS switches.

4) An operation counter to indicate the number of LBS switching cycles. The operation counter shall increment for electrical operations (both remote and local control) and for mechanical operations (e.g., hook-stick).

5) Other control panel features in accordance with manufacturer’s LBS design.

4.6 Distribution Automation System Interface

The LBS shall be monitored and controlled by the DAS. In this respect, the LBS’s integral RTU shall be capable of interfacing with the radio/modem to be provided and installed in the LBS control cabinet.

4.7 Control Cabinet

Each LBS shall include a pole-mounted control cabinet. The control cabinet shall house the LBS’s Local Control Panel, Switch Power Supply (SPS), and RTU and any other device as may be required in accordance with the LBS manufacturer’s design. Space within the cabinet shall allow for the installation of a remote radio as supplied and installed by others.

The control cabinet shall meet the following requirements:

1) All electronic parts shall be enclosed in modules that protect them from entry of small insects. The power supply module in particular shall be physically separated from all other modules.

2) The control cabinet shall be manufactured such that ingress of dust, vermin, and small objects is prohibited.

3) The electronic component modules within the control cabinet shall have a minimum protection level of IP 56 or better. The control cabinet itself shall have an overall protection level of at least IP 56 or better.

4) Holes with a metal screen shall be provided at the top and bottom of the control cabinet to provide ventilation in such a way as to avoid condensation within the cabinet while still maintaining the cabinet’s IP 56 or better protection level, i.e., such ventilation shall in no way reduce the effectiveness of the control cabinet’s water-tight, dust-tight, and corrosion-resistant characteristics. In this respect, the control cabinet shall be tested in accordance with the latest IEC standard.

5) The control cabinet shall have a hinged front access door with three-point latch locking system and latch operating lockable handle.

6) The opening of the cabinet behind the door shall have a perimeter flange and gasket (rubber or neoprene) to prevent the ingress of water.

7) The control cabinet shall include a weather-sealed hole with double compression cable gland, approximately 30 mm in diameter, on the bottom of the cabinet for routing the remote radio's antenna cable.

8) The control cabinet shall be fabricated from sheet steel CRCA of not less than 2 mm in thickness.

9) The finishing coat shall be grey (RAL 7032).

10) The control cabinet shall be suitable for mounting on poles consisting, for example, of reinforced cement concrete double-pole or single spun-pole structures.

11) The cabinet shall have a steel channel fixed to the back of the control cabinet for mounting purposes.

12) The control cabinet shall be provided with:

    a) Weatherproof fittings for control cables.

    b) Grounding terminal, with solder-less clamp type connector suitable for steel stranded conductor, complete with lock washer of stainless steel or better.

    c) Circuit diagram of control unit for maintenance purposes, to be affixed permanently and legibly marked

    d) Other items per manufacturer's design.

4.8 Auxiliary Power Transformer

The LBS shall provide a single-phase auxiliary power transformer of outdoor cyclo-aliphatic resin cast type. The transformer shall be suitable for phase-to-ground connection to the 11-kV distribution network in order to provide a 230 VAC, 500vA output for distribution to the SPS as used, for example, to power the LRC switch gear, RTU, and remote radio. The auxiliary power transformer shall be pole-mounted (ideally on the same pole structure on which the LRC will be mounted), and shall be properly earthed via a GI strip of suitable size.

4.9 Switch Power Supply

The LBS shall be equipped with a Switch Power Supply (SPS) consisting of batteries and battery charger. Power from the SPS shall be sufficient to supply the LRC equipment. This includes the RTU. It also includes the radio (supplied and installed by others).

The SPS shall meet the following requirements:

1) Battery standby time shall not be less than 8 hours and shall allow for a minimum of ten (10) sequences of LRC trip-close operations and a transmit/receive standby duty cycle of 10/90 percent with respect to the radio/modem.

2) The battery shall recharge to 100 % of its capacity in a maximum of 8 hours.

3) Under the above communications scenario, closing of the LRC circuit breakers shall be prevented if the battery does not have enough stored energy to open the breakers for a protection trip condition.

4) Batteries shall be disconnected at the manufacturer's specified minimum voltage.

5) “Battery Low” indications shall be available locally and remotely and shall include a battery test. The indication of "Battery Low" status shall allow for a further ten LRC switch operations. A “Battery Off” indication shall also be provided locally and remotely to show that the battery needs to be replaced.

   - The backup battery bank shall include 2 Numbers of Lithium Iron Phosphate (LiFePO4) (LFP) 12 VDC, 42Ah each.
   - Each Lithium Iron Phosphate (LiFePO4) battery system shall be provided with an integrated BMS providing : cell voltage and temperature monitoring, state-of-charge and state-of-health estimation, cell balancing, over/under-voltage, over/under-temperature, over-current and short-circuit protection.
   - Battery compartment shall feature a theft-proof enclosure of 2mm thick stainless steel (Grade 316, IP54 rated), secured solely by M8 shear-head vandal-proof nuts/bolts. Tamper detection via NC micro-switch on seams/hinges shall trigger a 100 dB piezoelectric hooter with LED strobe (latched, DC-backed), silenced via separate external "Acknowledge" button while retaining LED, and reset via distinct "Reset" button post-rectification; alarms integrate with RTU/SCADA. All wiring, including battery links and sensors, shall use armored cut-proof cables (2.5 sq mm copper with steel braid/sheath resistant to cutters/grinders).
   - Receptacles: 1 x 230 VAC (for test equipment)

6) The minimum battery life expectancy shall be 10 years at 25^{o}C.

7) The battery charger shall be fully temperature compensated.

8) The SPS shall supply 24 VDC power to the terminal blocks for the trip coil and close coil.

9) To prevent deep discharge of the batteries on loss of AC power, the battery charger shall automatically disconnect all circuitry fed by the batteries (except for the radio) following

a user-adjustable time period or when the battery bank voltage falls below a preset value. If the voltage falls below the preset value, the time to fully recharge all batteries shall not exceed 8 hours.

10) In order to prevent serious battery discharge, the direct current power will be cut off when voltage stays under the minimum preset value.

11) An automatic battery checking device shall be provided to check the health of the batteries and initiate a battery failed alarm signal in case deterioration is detected. Detection may be based on a comparison of measured values versus setting or nominal values, e.g., internal resistance, voltage, etc.

12) Battery chargers shall be provided with the following alarms as a minimum:

    a) Low battery voltage alarm

    b) High battery voltage alarm

    c) Battery failed alarm

    d) Battery charger overvoltage alarm

    e) Grounded battery or battery-charger alarm

    f) Battery Temperature

    g) Others according to manufacturer's design

16) Each alarm indicator shall be displayed on the local control panel and as in Table 5-1 for remote indication.

17) The SPS shall provide the radio with a stable - 12 VDC source of power for Radio/ Modem.

4.10 Measurement Functions

The equipment supplied with the LBS shall meet the following requirements with respect to the measurements to be derived from primary voltage and current values:

1) Measurements shall be carried out by the three-phase, 3-wire method and/or the three-phase, 4-wire method and shall be made available locally and remotely.

2) All three phase voltages shall be measured on both sides of the LBS and, on this basis, shall be used to identify the live and dead sides when the LBS is in the open position.

3) All three phase currents shall be measured.

4) The following list identifies the minimum required measurements and accuracies:

a) Phase Voltage (V) …….... ±2.5% of rated voltage

b) Phase Current (A) …… ±2.5% of rated current

c) Three phase active Power (kW) …….. ± 5 %

d) Three phase reactive power (kVAr) …… ± 5 %

e) Total three-phase active energy (kWh) …... ± 5 %

f) Power factor ...…….. ± 5 %

g) Maximum demand ……... ± 5 %

3) Energy values shall be calculated with selectable time integration periods of 15, 30, or 60 minutes. The data buffer shall work on the FIFO principle and shall have the capacity to store the required energy values for 1 week based on a 60 minute integration period.

4) The LBS shall have the facility to record the number and duration of outages. The information shall be accessible locally as well as remotely at the DAS.

5) The following parameters shall be recorded and made available locally and at the DAS:

a) Cumulative total number of outages

b) Cumulative total outage duration

c) Time and duration of each outage

d) Number of switch operations

4.11 Earthing

Two No's of separate Rod type earthing to be provided. The earthing has to confirm to relevant IS. The details of earthing to be provided are as given under:

1. Auxiliary Transformer neutral, Auxiliary Transformer body, Auto Reclosers body, control cabinet and all other metallic parts of the structure to be earthed separately using 25 x 3 mm GI strip.

2. Surge arrester / Lighting arrester to be earthed separately using 25 x 3 mm GI strip.

5. Remote Terminal Units

This clause describes the Remote Terminal Unit (RTU) requirements that will enable the DAS to monitor and control the Contractor-provided sectionalizers for the purpose of providing the SCADA/DMS functions executing in the DAS with real-time feeder data such as the Fault Location Isolation and Service Restoration (FLISR) application. This DAS application will be used to detect and isolate permanent feeder faults and restore power to otherwise unaffected feeder sections. Monitoring shall allow the DAS to perform diagnostic tests on the sectionalizer equipment. In addition, with respect to Line Reclosers, control shall allow the DAS to adjust switch protection parameters.

The RTUs shall include all hardware, software, and firmware necessary to meet the Input/Output (I/O) point requirements associated with the sectionalizers. Each RTU shall be an integral part of the Contractor's sectionalizer design. It shall be installed in the sectionalizer's control cabinet.

The RTU shall be modular and easy to install, operate, and maintain. It shall consist of the following main components:

- Chassis for all electronic modules
- Switch connection module
- CPU and local control indication module
- RTU communications module

5.1 Data Acquisition

Each I/O module in the RTU shall be capable of interfacing with analog inputs, digital inputs, control output points, and combinations of point types. I/O modules shall be replaceable without reprogramming, redefinition of configuration parameters, or rewiring.

The RTU shall be capable of reporting the state of all status points upon receipt of a demand scan, i.e., a general interrogation request from the DAS. The state of each status point shall also be capable of being reported to the DAS on a report by exception basis. In this case, a status point shall not be reported unless the point has changed state from the last scan. Alternatively, the RTU shall be capable of reporting changes of state on an unsolicited basis, i.e., independently of the DAS.

The RTUs shall also be capable of reporting all analog points upon receipt of a demand scan. This shall include a report by exception capability, whereby the RTUs shall report only the analog points that have changed by more than a programmable deadband from their last values successfully reported to the DAS. The deadband shall be specified for each point individually. In addition, the ability of the RTU to alarm analog high and low limit violations shall be supported. As for status points, the RTU shall also be capable of reporting changes to analog values on an unsolicited basis.

The digital and analog inputs to be accommodated by each type of sectionalizer RTU are presented in Table 5-1.

5.2 Device Control

The RTUs shall allow the DAS to send control commands to the sectionalizer as required to open and close the sectionalizer switches remotely. The RTUs shall perform such control using complimentary pairs of contact outputs. One contact output shall perform the “Close” action, and a second output contact shall perform the “Open” action. The RTUs shall be designed such that only one output in a complimentary pair can be activated at a time.

To support the above capabilities, the RTUs shall include momentary control outputs as required by the sectionalizer device being controlled. Each momentary control output shall provide a contact closure pulse with a programmable pulse duration.

All control points shall follow a Select-Checkback-Before-Operate (SCBO) procedure. The SCBO procedure shall be equivalent to the following:

a) The point selection command is received from the DAS.

b) The RTU checks that no other point is selected.

c) The RTU selects the addressed point and transmits a select confirmation to the DAS.

d) The RTU starts the command receipt timer and checks that only the required point remains selected and no other points become selected.

e) The operate command is received from the DAS.

f) The RTU verifies the operate command and energizes the selected control point relay for a predetermined time.

Point selection shall be canceled automatically following the completion of the control action. Subsequent control actions shall require point re-selection.

Control from the DAS or RTU test set, shall only be enabled if the sectionalizer Local/Remote switch is in the “Remote” position. A status input contact shall be available to monitor the position of this switch. The switch position shall be reported to the DAS.

5.3 Time-Stamped Events Logging

The RTU shall time-stamp events with a resolution of 10 milliseconds or better. It shall have an event buffer to store these time-stamped events with a capacity of at least 50 events.

Data logged events recorded in the RTU shall be capable of being read from a sectionalizer test set connected to the RTU as well as from the DAS.

5.4 Input/Output Point Counts

The number of input/output points shall be consistent with the Contractor's standard SCADA-ready sectionalizer design. As a minimum, however, the number of points presented in Table 5-1 shall be provided. This includes provision for a number of spare points that shall be wired from the RTU I/O card to associated terminal strips in the control cabinet.

Table 5-1: Input/Output Points

Line Recloser:

STATUS INPUTS	ANALOG INPUTS	CONTROL OUTPUTS
Switch Open Switch Closed Mechanical Lever Locked Mechanical Lever Free Reclose Blocking Ground Trip Blocking On/Off Local/Remote Switch Position Overcurrent Relay Operated Earth Fault Relay Operated Operated Hi set on OCR, EFR SEF Relay Operated Battery AC power Battery Voltage Battery charger voltage Battery Grounded/Failed Battery Compartment open Door Open Alarm Fault passage indication Control lock enable/disable Protection blocked Battery Temperature Along with 10 spare	3 Currents 6 Voltages 4 Maximum Fault Currents 1 Active Power (calculated) 1 Reactive Power (calculated) 1 Active Energy (calculated) 1 Power Factor (calculated) 1 Operation Counter (calculated) %THD I (current) Phase angle Power angle Forward relay group Reverse relay group Along with 10 spare	Switch Open Switch Close Non-Reclosing Ground Trip Block FPI reset Activate reverse flow Protection enable/disable Hooter reset Along with 10 spare

Load Break Switch:

STATUS INPUTS	ANALOG INPUTS	CONTROL OUTPUTS
Switch Open Switch Closed Mechanical Lever Locked Mechanical Lever Free Battery AC power Battery Voltage Battery charger voltage Battery Grounded/Failed Battery Compartment open Local/Remote Switch Position Fault Passage Indication Door Open Alarm Battery Temperature Along with 10 spare	3 Currents 6 Voltages 1 Active Power (calculated) 1 Reactive Power (calculated) 1 Active Energy (calculated) 1 Power Factor (calculated) 1 Operation Counter (calculated) %THD I (current) Phase angle Power angle Forward relay group Reverse relay group Along with 10 spare.	Switch Open Switch Close FPI reset Hooter reset Activate reverse flow Along with 10 spare.

5.5 RTU Communications Interface

The RTUs shall have two ports available for the primary means of communicating with the DAS via the Employer's Communications System. One shall be an Ethernet TCP/IP (RJ45) port, and shall be a Serial RS-232C & 485 port.

The RTU Ethernet and Serial ports shall be configured with the DNP/IP and DNP 3 or other communications protocols respectively. The protocols shall be implemented by modifiable firmware in the RTU. No external gateways for protocol conversions shall be used.

The RTU shall support both Cold Reset (full power-cycle emulation) and Warm Restart (software-initiated reboot) commands initiated remotely from the DAS.

The RTU and Protection Relay shall support the Remote Download of Configuration Files from the DAS/SCADA center. This functionality must be achieved without interrupting the primary protection functions of the device.

For metering purposes, the RTU shall support Frozen Counter functionality for energy values, including a Rollover Bit to indicate when the counter has exceeded its maximum value and returned to zero.

The RTU shall support the DNP3 protocol as per IEEE 1815, specifically implementing and demonstrating Secure Authentication (SAv5). This must include support for pre-shared keys, user authentication, and integrity checks to prevent unauthorized control or spoofing and shall support IEC 61850 GOOSE messaging to facilitate horizontal (peer-to-peer) communication between sectionalizers.

The RTU and associated DAS interface shall strictly adhere to the latest cyber security guidelines issued by NCIIPC and the Ministry of Power, GOI. The Contractor shall ensure that the equipment is sourced from 'Trusted Sources' and 'Trusted Products' as defined by the Government of India. Evidence of compliance with IS 16335 and CEA (Technical Standards for Connectivity to the Grid) Regulations shall be provided during the design approval stage." under Clause 5.8.

The RTU and control system shall be designed and certified in compliance with NERC-CIP and IEC 62443 standards. The contractor must provide evidence of testing and certification from an accredited third-party laboratory.

5.6 RTU Time Synchronization

The RTUs shall have an internal clock for data collection coordination and time tagging with a drift of no more than 10 seconds per day. To meet this requirement, the RTU may apply a time correction algorithm. Otherwise, a clock with an accuracy of 100 ppm or better shall be provided.

The RTU time source shall support the capability of the RTU to time tag operations data (i.e., real-time data) and, for possible future application, non-operations data used for post-mortem analysis. The non-operations data could include power quality data such as disturbance and waveform records.

Each RTU shall synchronize its internal clock from the DAS through the DNP communications protocol. Alternatively, should it be necessary, the RTU shall support time synchronization via the Network Time Protocol (NTP).

5.7 RTU Software/Firmware

The RTUs shall meet the following software/firmware requirements to support the functions of the RTUs. The term firmware, as used herein shall mean PROM-based software which may be provided to satisfy the Employer's requirements. The Contractor shall use standard firmware as much as possible.

5.7.1 Design Characteristics

All firmware shall be completely and consistently documented. It shall not be necessary to perform modification to firmware, logic, or data for expansion within the sizing parameters defined for the RTU.

At the time the RTU is accepted, all firmware delivered must be up to date and in final form, including all standard firmware changes and field changes initiated by the Contractor or any associated sub-contractor prior to acceptance. The firmware documentation must reflect these changes.

5.7.2 Initialization/Restart Program

Firmware shall be provided to enable the RTU to safely restart itself upon manual request and automatically under the conditions of power restoration, memory parity errors, and hardware failures. The firmware shall initialize the RTU and begin execution of the RTU functions without intervention by the DAS. All RTU restarts shall be reported to the DAS.

5.7.3 RTU Operations Monitoring Firmware

Firmware shall be provided to continuously monitor operation of the RTU. The firmware shall check for memory, CPU, communication faults, and input/output errors and failures. All detected errors shall be reported to the DAS.

5.7.4 Fail Safe Processing

In the case of irrecoverable faults such as power supply failures, firmware malfunctions, or any other detected condition that may affect the security of indications and controls, the RTU shall place itself in a secure state that prohibits the transmission of false indications or the execution of erroneous control outputs. The detection of these error conditions shall be the responsibility of the RTU's self-test and operations monitoring firmware.

5.7.5 Database Maintenance

The Contractor shall supply software to configure each RTU's database where this information is located in software and/or firmware at the RTU. The software shall completely generate or modify the

database of the RTU. The database software shall have error detection services and shall produce a printed listing of the input data and the resulting RTU database configuration.

The RTU shall support changes made to the RTU's configuration and processing parameters (such as measurement deadbands) by downloading relevant data from the DAS. The contractor shall provide a single file for download. The RTU shall display the name and version of the current Configuration file in the RTU web page.

The RTU shall support deadband functionality with both read and write capability. It shall be possible to configure, modify, and read back deadband values for analog points from the SCADA/DAS system or engineering workstation without requiring RTU restart.

5.7.6 Diagnostic Firmware

The Contractor shall supply diagnostic firmware for both off-line local tests and on-line self-diagnostic capability built into the RTU. The RTU shall enter an off-line state during the execution of off-line diagnostics, and this off-line state shall be reported to the DAS.

5.8 Diagnostic Ports

The RTU Ethernet and Serial communication ports shall be capable of being used for remote diagnostics from the DAS and from any external computer terminal with a suitable communications connection. This shall include the capability to support auto-answer dial-in operations.

5.9 Cybersecurity Requirements for LRC & LBS:

5.9.1 General Compliance

The Vendor shall ensure that all RTU of LRC & LBS, are designed and manufactured in accordance with the following international standards:

IEC 62443-4-1: Secure Product Development Lifecycle Requirements.

IEC 62443-4-2: Technical Security Requirements for IACS Components (Target: Capability Security Level 1 - SL1).

IEC 62351: Power systems management and associated information exchange – Data and communications security.

5.9.2 Identification and Authentication Control (IAC)

Local Authentication: The device must support local password-based authentication for both the HMI (Human Machine Interface) and any engineering ports (USB/RS-485/Ethernet).

Default Credentials: The device shall not have "hard-coded" or universal passwords. The Vendor must provide a mechanism to force a change of the factory-default password during the commissioning and also allow changing passwords.

Access Lockout: The device shall implement a temporary lockout or "cool-down" period after a configurable number of failed authentication attempts (Min: 3 attempts) to prevent brute-force attacks via the engineering port.

5.9.3 Use Control and Port Security (UC)

USB Port Management: The relay must disable "Autorun" or "Autoplay" functionality. No configuration file or firmware shall be executed or imported automatically upon USB insertion.

Manual Confirmation: Any data transfer (Upload/Download) via the USB interface must require explicit manual confirmation through the device's HMI after successful login.

Unused Ports: The vendor shall provide the capability to logically disable unused communication ports (e.g., RS-485 or Ethernet) via the device configuration settings.

5.9.4 System Integrity (SI)

Firmware Integrity: The device must perform a cryptographic checksum (e.g., SHA-256) or hash verification on all firmware updates before installation to ensure the file has not been tampered with.

Logic Protection: Protection settings, trip logic, and configuration parameters must be stored in a non-volatile memory that is protected against unauthorized modification.

5.9.5 Audit Logging and Monitoring (RA)

Security Event Logging: The device shall maintain an internal, non-volatile audit log that records at least the last 50 security-relevant events, including:

Successful and failed login attempts.

USB/Engineering port connection and disconnection events.

Modifications to protection settings or system configurations.

Firmware update attempts (Success/Failure).

Exportability: Log data must be viewable via the engineering software and, if network-enabled, exportable via standard protocols (e.g., Syslog or IEC 61850).

5.9.6 Vendor Documentation Requirements

The Vendor shall submit the following documents as part of the technical bid:

Hardening Guide: A step-by-step document explaining how to secure the device (e.g., changing passwords, disabling ports).

Vulnerability Management Policy: A statement on how the vendor identifies and notifies customers of security vulnerabilities (CVEs) in their products.

Self-Attestation: A formal letter confirming that the device meets the Capability Security Level 1 (SL-C 1) requirements of IEC 62443-4-2.

5.10 Outstation Device Profile Recommendation

Outstation device profile recommendation will be as below:

Functionality	DNP Objects to be supported (All its variations are to be supported)
Time Synch	50
Status Values	2
Analog Values	30
Analog Deadbands	34
Analog Outputs	41
Counters	21
Control	12
Default Poll (Status): Digital Inputs Binary Outputs Binary Counters Frozen Binary Counters Analog Inputs Analog Outputs	1 10 20 21 30 40
Double bit Binary Input	3
File	70
Authentication	120
Security Statistics	121
Online/Offline Processing at the RTU	
CROBs (Control Relay Output Blocks)	
Function Code	Function
0	Confirm
1	Read
2	Write
3 and 4	CROBs (Select and Operate)
13 and 14	Cold and Warm Restart
19	Save Configuration
20	Enable Unsolicited Responses
21	Disable Unsolicited Responses
23	Delay Measurement
24	Record Current Time
25	Open File
26	Close File
27	Delete File
30	Abort File
28	Get File Information
29	Authenticate File
31	Activate Configuration
32	Authentication Request
33	Authentication Requeste No Acknowledgement
129	Response
130	Unsolicited Response

131	Authentication Response
Static Data and Event Data	Group 60
Binary Inputs	Group 1
Double-bit Binary Inputs	Group 3
Binary Output Status	Group 10
Counters and Frozen Counters	Group 20 and 21
Analog Inputs and Frozen Analog Inputs	Group 30 and 31
Analog Output Status	Group 40
File Transfer Objects	Group 70
Authentication	Group 120
Security Statistics	Group 121
Analog Input Reporting Deadbands	Group 34
Internal Indications	Group 80

6. Test Sets

The Contractor shall supply 6 Numbers of sectionalizer test sets in the form of notebook PCs with latest Windows OS with anti-virus & valid license. Each test set shall be capable of being used to perform tests on both the Contractor-supplied line reclosers and load break switches including their RTUs. In this respect, the test set as a minimum shall comply with the following requirements:

1) It shall support all maintenance aspects such as verifying proper operation, troubleshooting, reconfiguring, and setting applicable operational parameters for the sectionalizers and their RTUs.

2) It shall support all functional capabilities of the sectionalizers and RTUs including functions that are not explicitly required in these Technical Specifications and functions that may not be included in the delivered sectionalizers and RTUs.

3) It shall be possible to use a test set at the sectionalizer site and also remotely wherever access can be obtained to the communication channel of the RTU.

4) All the required data rates shall be easily selectable.

5) The test set shall be equipped to support FTP and, in particular, the DNP 3.0 and DNP over IP communication protocols.

6) The software used by the test set shall include the functional capabilities and features associated with commercially available test equipment. The software must be capable of offline updates and configured to prevent the spread of malware during field testing and commissioning.

7) It shall be possible to use the test set to monitor communications between the DAS and the RTU by selecting specific data streams, or portions of such data streams, both to and from an RTU. The data shall be displayed in a form that is easy for the user to interpret.

8) It shall be possible to connect the test set directly to the RTU and to use it to perform all necessary RTU management and expansion functions, monitor all stored data, monitor RTU inputs, exercise RTU outputs, and diagnose and troubleshoot the RTU. It shall also be possible to use the test set as a local user interface for the sectionalizer as well as the RTU.

9) No programming skills shall be required to use the test set. Interactive procedures relying mostly on pull down menus shall be used. The user shall not be required to type in commands and shall be prompted when data entry is needed.

10) Each test set shall include at least two communication ports and all necessary interface connectors and cables to allow its direct on-site connection to the RTU communication ports used for normal DAS operations as well as diagnostic and configuration activities.

11) The test set shall be ruggedly constructed and suitable for field work and transportation in trucks. It shall be delivered with a case sufficiently sized to contain and safely protect all of its components. All cables, connectors, equipment, and documentation associated with test set operation shall be included and stored within the test set package or in suitable separate containers.

12) Operating System: Must be a currently supported version of Windows Pro (latest version), hardened by disabling non-essential services, guest accounts, and unused ports (Bluetooth/IR). Disable "Auto-run" for all removable media as a part of USB hardening.

13) User Account Control (UAC): Field technicians should use a "Standard User" account for daily testing. Admin privileges should only be used for software installation or critical configuration changes, protected by a strong password or biometric.

7. Surge Arrester Characteristics

Provision shall be made to supply and install 11-kV surge arresters as necessary to protect the Contractor's sectionalizer equipment. The surge arresters shall comply with applicable international standards and specifications.

The arresters shall have the following main features:

- Vandal-proof (shatter-less) housing
- High cantilever and torsional strength
- Usable for support insulator
- Pollution resistant
- Optional use of ground disconnect device
- Stud or bracket mounting
- Stable characteristics
- Long-life with proof of ageing

- Maintenance free
- Easy to install
- Impervious to moisture ingress
- Lightweight and of compact dimensions
- Complete with all necessary installation accessories such as suitable wiring and connectors for earthing purposes.

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